THE VARIABLE CHARACTER OF THE VEGETATION ON BASALT SOILS.

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In my papers to the Society on the Glass House Mountains, and the East Moreton District of Queensland, I emphasised the point that, in these parts, the basalts were invariably covered with dense scrubs, whereas the sandstones and trachytes supported only a forest-flora. In my paper on the Geology of Mt. Flinders and the Fassifern District, I pointed out that, around Engelsburg, the trachytes were covered with scrubs, whereas the basalts in all the vicinity could boast only a sparing amount of forest.

Still more recently, Mr. R. H. Cambage, F.L.S., in the Proceedings, has called attention to the want of forest-vegetation on the basic rocks of the Monaro Plains, while the more acidic granites and porphyries, in that same district, support a fair amount of forest.

An observer acquainted only with the barren basaltic outcrops which occur isolated on the Western Plains, and in the Murrumbidgee basin, might well look upon basalt as a curse from an agricultural point of view; while it is hard to dissuade the man who has traversed the Darling Downs of Queensland from looking upon basalt as the source of our richest agricultural lands.

It is the object of the present note to explain why so many types of vegetation occur on basalt in different parts.

The character of the vegetation on any geological formation depends essentially on three factors—(1) the mechanical and chemical composition of the soil; (2) the character of the subsoil; and (3) the climate and climatology.

Before proceeding to discuss general principles, I desire to review the various types of vegetation which I have observed on basalt-formations. They will be dealt with in the order of their extent and importance.

A. *Basalt Scrubs* (Jungle-forests or Brushes).—Wherever sheets of basic lava cover large areas in the coastal districts of Queensland, or of New South Wales north of the Nambucca River, magnificent "scrubs" are found to be coextensive with the basalt-formation. Only here and there may a patch of forest-country be seen, and on closer examination it will always be found that such a patch is accounted for by either—

(*a*) Rapid drainage of the soil, as on the summit of a peak or of a razorback range; or

(*b*) The existence on the spot of a formation of porous tuff; or

(*c*) The presence of a felspar-basalt, porphyritic in acid plagioclase, which, by resisting weathering longer than the other constituents, gives a more sandy and porous texture to the soil.

So that where a forest-patch is found on basic volcanic rock in a tropical or subtropical coastal area, the occurrence is always due to superior porosity and drainage of the soil. The forest-trees which predominate on such patches are always those which are typical of good soils on other formations, namely, box, ironbark, apple, and blue-gum.

In isolated places where a depression without an outlet occurs in basalt country, either on a peak or on a plateau, an absolutely treeless stretch of country may occur. The only vegetation consists of reeds and brush. Such barren areas are the result of complete absence of drainage, leading to the soil becoming sour, and the soil-water becoming saturated with soluble salts deleterious to plant-life.

B. *Basalt Plains.*—West of the Great Dividing Range, large basalt-areas are almost treeless. The Darling Downs possess only a few straggling trees on the small knobs or hillocks, which are dotted over it at intervals. The hillocks invariably possess a more stony and porous soil than the level country, hence the trees can take root. In New South Wales, similar facts may be

observed both in New England and on the Liverpool Plains.

C. *Basalt Knolls.*—In the western interior of New South Wales, smaller isolated basalt-areas are abundant, and are often so extremely stony and bare of soil as to be useless for anything but sheep-grazing.

D. *Basalt Ranges.*—In the southern coastal districts of New South Wales basaltic ranges, like the Cambewarras, occasionally occur. These are partly clad with forest, and partly with a scrub somewhat less dense and luxuriant than the northern ones.

E. *Basaltic Bogs.*—On the Southern Tablelands, and in the Australian Alps in particular, there are many elevated basaltic plains with a poorly developed drainage. In such places the soil is cold, sour, and charged with mineral salts to such an extent that forests cannot establish themselves. Sedges, grasses, and reeds alone are able to exist.

Having now described the different types of basalt-country, it becomes necessary to define what factors control the vegetation of each.

A. *Basalt Scrubs.**—These are all found in tropical or semi-tropical, damp, or rainy climates. Rock-weathering is rapid and penetrates deeply, because water charged with organic acids sinks into the rock, and chemically attacks it. The soil is consequently deep as well as fertile. The dense scrub prevents the products of rock-decomposition from being rearranged in layers, or mechanically transported to any extent, except on steep slopes. The subsoil, therefore, is generally similar to the surface-

* "These are, properly speaking, forests, tropical forests with the character of the Indian jungles. . . . . I think it would be better if the term "scrub" were not applied to these forests. They are so utterly different from what is included under that name in other parts of the Colony, that jungle would be a far better expression. . . . . In the true Australian scrub usually one or two species predominate, in fact almost exclude every other. The jungle forests are of a much more mixed character. No one genus or even species gives its character to the forest. . . . . In New South Wales, such forests are called 'Brushes.'" [Tenison-Woods, Botanical Notes on Queensland, No. v., The Forests or Scrubs. These Proceedings, vii., pp. 538-569, 1882(1883)].

soil, though somewhat richer in mineral plant-food. The Blackall Range Scrubs, in South Queensland, are of this type. The soil is chemically very rich, and consists of dark brown or black clayey loams. It has high water-retaining power, but low porosity; and always suffers from sourness, and lack of aëration. This is, however, no disadvantage to the typical scrub-plants, which will flourish only in sour, heavy, and wet soils. On steep slopes, the soils of basaltic scrubs may, through leaching, be poorer than usual in this type of country.

B. *Basalt Plains.*—The soil of these areas has the same characteristics as that of the scrubs, namely, depth, richness in plant-food, high water-capacity, low capillary power, and lack of aëration. The cause which produces the dearth of vegetation is, that those Australian trees which can live in heavy, impervious, unaërated soils, namely the scrub-flora, are prevented from establishing themselves by the lack of rainfall, and sometimes by the cold climate of the tableland as well. It is more difficult to see why the forest-vegetation of more acid formations has been unable to adapt itself to the much richer soil of the basalts. If the typical forest-flora of Australia is very old, as we have reason to believe, it is reasonable to suppose that it possesses an hereditary aversion to soils of a heavy, clayey nature.

Prior to the Miocene, there was little basic rock in Eastern Australia, and the greatest basalt-areas are still later, namely, Pliocene. Before the great basaltic extravasations, almost all the soils of this continent were of a loose, porous, sandy nature. Such soils, though poor in plant-food, are not only well aërated, but are also able to supply any deficiency in rainfall by absorbing moisture from the dew or from the atmosphere by capillarity. If heavy rains fall, the surplus water readily drains away. But the basaltic soils, of the Miocene and Pliocene outpourings, are heavy, clayey, impervious to air and water. They have so high a water-capacity, and so poor a porosity, that in heavy rains they become water-logged, and the tree-roots are suffocated; while in a prolonged drought they dry up to such an extent that the trees die of thirst, the capillary power of the soil being so slight that

dew and atmospheric vapour cannot find their way down. For these reasons, the forest-flora, specially adapted for the silicious porous soils, has never been able to transplant itself to the basalt-areas.

It is also possible that the cracking of these heavy soils, in dry weather, may fracture and tear tree-roots to such an extent, that forests are unable to establish themselves.

C.—The *Basalt Knolls* of the western interior owe their bareness to two causes. In the first place, basalt is such a compact, homogeneous, and even-grained rock that, in an arid climate where organic acids (from decomposing vegetation) and moisture are at a minimum, decomposition is extremely slow. Granite, porphyry, and sandstone are much more readily disintegrated by heat and frost. In the second place, the minerals of basalt are all decomposed with about equal readiness, there being no specially hard and resisting mineral, like the quartz of granite. Therefore, the soil formed by the disintegrating basalt is very finely divided, and is readily blown away by the wind. The wind practically removes the soil as fast as it is formed, on the basalt knolls of the arid interior.

D.—The basalt-ranges of the south of New South Wales along the coast, differ from the Queensland ones in having a colder climate, and lower rainfall, two factors which prevent a semi-tropical, true scrub from establishing itself. Rapid corrosion and erosion, unhindered by dense vegetation, have given rise to steep slopes, which again have been the cause of such an excellent natural drainage, and such a stony soil, that forest-vegetation has had no difficulty in asserting its supremacy.

The basaltic ridges of the Little Liverpool Range and Fassifern District of Southern Queensland owe their forest-flora to a similar cause. The climate of this region is much drier than that of the coast, but wetter than the Darling Downs, whose eastern flank is formed partly by these ridges. Springs never occur here in the basalt-lavas, and the slopes are steep. Consequently we have here conditions intermediate between those of the scrub-decked coastal basalts, and the bare plains of the Downs. The soils,

being rapidly removed by streams and rain-torrents on the steep slopes, are fairly shallow and stony, well drained and porous, hence a healthy forest-vegetation has been able to establish itself.

E.—The *Basaltic Bogs* of plains and tablelands owe their want of a forest-flora to inefficient drainage. The soil is water-logged and the soil-water is charged with salts which are detrimental. The roots of trees would get suffocated and would rot.

It will be seen from the above account that the defect of basaltic soils is never want of plant-food. The worst faults are high water-capacity, which causes the drowning of plants in wet weather; and the low capillary power, which impedes a renewal of soil-moisture in droughty seasons. Silicious soils lose their moisture quickly enough, but they are able to get supplies from the subsoil, because of their high capillary power and porosity.

Chemical Composition of Basalt-Soils.

The following table gives some idea of the comparative value of different soils, based on their manurial ingredients (Table i.). The richness of the basalt soils is indisputable, and it is only their mechanical condition which is adverse to always getting good results. They must be kept in a continual state of aëration by frequent ploughing, and any cereal crops which do not root too deep will flourish on them. The addition of substances which will increase the capillary power, such as sand and sawdust, can always be employed to improve the texture of heavy basalt soils.

The Richmond River volcanic soils, whose average composition has been calculated by Mr. Guthrie,* will be seen to be rather poor in potash as compared with the other basaltic soils. This is due to the dense vegetation in the Northern Rivers district. The sandy soil from the Pilliga scrub, which is covered with a dense pine jungle, is likewise deficient in potash as compared with Hawkesbury Sandstone soil.

Although basalt-soils are generally of good quality, they may in certain situations be reduced by leaching to the condition of

* Agricultural Gazette of New South Wales, 1900.

TABLE I,

SHOWING AVERAGE COMPOSITION OF SOILS TYPICAL OF VARIOUS GEOLOGICAL FORMATIONS.

Geological Formation.	Number of Analyses Averaged.	Dominant Colour.	Usual Reaction.	Mean Water-Capacity. %	Capillary Power.	Mean Clay %	Lime, CaO. %	Potash, K_2O. %	Phosphoric Acid, P_2O_5. %	Nitrogen, N. %	Volatile. %
Slate	3	light	acid	28·2	good	41·6	0·066	0·055	0·069	0·066	4·26
Hawkesbury Sandstone	over 100	light	acid	low	good	low	0·106	0·066	0·137	0·133	7·22
Pilliga Scrub Sandstone	1	light	acid	2·9	good	13·0	0·152	0·019	0·045	0·056	9·75
Granite	128	light	acid	37·7	good	38·0	0·190	0·140	0·109	0·103	5·34
Basalt	5	dark	neutral	48·8	low to fair	63·4	0·565	0·084	0·107	0·170	8·00
Limestone	10	dark	alkaline	44·9	fair to good	56·4	0·765	0·350	0·181	0·104	6·76
Alluvials	5	dark	neutral	46·0	fair to good	84·8	0·686	0·242	0·291	0·165	8·28
Black Soil Plains	6	dark	neutral	62·7	very poor to good	78·0	0·635	0·330	0·174	0·092	7·00
Volcanic, Richmond River	—	light	acid	52·0	good	25% to 75%	0·210	0·080	0·300	0·300	16·00

clays composed of iron-oxide and alumina (laterite and bauxite clays), and rather deficient in mineral plant-food. This would be particularly the case on a naturally well drained basaltic plateau, when the basalt is rich in alkali, and the rainfall is good. Then the dense scrub-vegetation extracts the potash as fast as it is liberated; carbonic acid and ammonia generated by the decomposing vegetation and other organic matter, sink into the subsoil, and leach out of it the lime and silica respectively. The soda likewise filters away in solution.

As an instance of this, one might quote an analysis of basaltic subsoil from Cape Diego, in North Madagascar, which gave the following result :—

Insoluble residue	...	...	81 per cent.
Sesquioxide of iron	...	...	19 ,,

There was no lime, no alumina, very little potassium and phosphoric acid. The surface soil was richer, containing—

Nitrogen	...	...	0·17 to 0·79 per cent.
Phosphoric acid	...	...	0·15 to 0·44 ,,
Potassium	...	...	0·01 to 0·07 ,,
Lime	...	...	0·00 to 0·03 ,,

Where the soil is alluvial, though of basaltic origin, redistribution of ingredients, and leaching will, of course, frequently give rise to layers of poor, clayey soil.